**Meta-Analysis of Inquiry Learning Models in Physics Learning**

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Abstract

This study aims to analyze the effect of inquiry in physics learning which can be viewed in terms of education, results, materials, and research on the learning media used. The method used is Meta-Analysis with the research flow, namely determining the research topic, setting data criteria, searching for data, classifying data, analyzing and drawing conclusions. Data collection techniques using secondary data from 23 relevant articles from previous scientific publications. The data analysis technique uses effect size. The results of this meta-analysis conclude that the application of the inquiry learning model has a significant effect on physics learning, with an effect size value of 1.216. The application of inquiry in physics learning has a considerable impact if applied to the elementary school education level by producing outputs that increase understanding of concepts, use light subjects, and help learning media in worksheets.

**Keywords:** Inquiry Learning, Meta-Analysis, Physics Learning

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# **introduction**

Based on the results of a survey by Programmers For International Student Assessment (PISA), the acquisition of scientific achievement results based on an international study in 2018 shows that students still have not optimally obtained maximum results in science abilities. Indonesia is ranked 70 out of 78 countries. The survey covers aspects of assessment, including the knowledge, competencies, and attitudes of students related to physics and biology (OECD, 2020). So when viewed by paying attention to these conditions, it should be necessary to improve the quality of education in Indonesia by optimizing the appropriate learning model. For assessment, the PISA 2018 definition of scientific literacy can consist of three interrelated aspects, as shown in Figure 1.

*"Effective teaching gives rise to effective learning, and students' learning can come in all forms, one of them being learning to think at the higher levels"*. Teaching can be effective if learning enhances thinking skills, and knowledge can come from all directions (Tan & Halili, 2015). Bakry, Md Nor (2015) states that students' thinking skills with high, medium and low level measuring instruments in solving different HOTS questions where students have high thinking skills can achieve aspects of creating, expressing opinions and providing conclusions. In other words, students who have moderate thinking ability reach making and express opinions but cannot conclude. While students have low thinking ability, they cannot achieve the aspects of creating and concluding.

**Contexts**

* Personal
* Local/National
* Global

Require individuals to display

**Competencies**

* Explain phenomena scientifically
* Evaluate and design scientific Enquiry
* Interpret data and evidence scientifically

How an individual does theis is influenced by

**Knowledge**

* Content
* Prosedural
* Epistemic

Figure 1 Inter-relations between the Three Aspects of Framework for PISA 2018

(OECD, 2018)

Based on the national curriculum of Indonesia, some of the essential competencies need to carefully prepare these learning materials with higher-order thinking skills, commonly referred to as HOTS (Muspawi, Suratno, & Ridwan, 2019). Various kinds of learning models can be applied to students. Still, the learning model will be successful if it is applied with appropriate learning materials and media assistance for the characteristics of students. One of the proper learning models used is the inquiry learning model.

According to Budiyono & Hartini (2016), the inquiry learning model is a learning in which students can plan and conduct experiments, collect and analyze data, also conclude with orientation in the problem-solving process to influence students' understanding during the learning process. According to Khoirul (2017), there are characteristics in inquiry learning, namely 1) students can become more optimally concentrated; 2) students can seek and find their answers from every activity in developing self–confidence; 3) students can develop an understanding of their potential systematically, logically, and critically.

The results of an experimental study on the topic of inquiry were conducted and published in the form of scientific articles by Nurhasanah (2020); she found articles in 11 national journals from 30 journals, both accredited and unaccredited, of which 11 journals were verified journals. While in the 2015-2021 range using the keyword "*Inquiry Learning Model in Physics*", there were 996 articles. The article results were searched using *publish or perish* with the google scholar search engine, as shown in Figure 2.



Figure 2 Search Results using *Publish Or Perish* with Google Scholar

 From the search results by using *publish or perish,* these have different research results and can affect the abilities and skills of students. The study took several topics related to the Inquiry Learning Model in Physics. As for some previous studies, there was an influence in the application of worksheets to train critical thinking skills and had a good and reliable level of validity. Besides that, it could affect the mastery of physics concepts (Andayani, 2020; Suliati, Mahrizal, 2016), (Fadhila, Arifuddin, & Miriam, 2018); (Saputra, Al Auwal, & Mustika, 2017); (Junaidi, Gani, & Mursal, 2016); (Yolanda, Gunawan, & Sutrio, 2019). Another research concluded that learning consisted of several stages: conservation, proportional, control variables, correlation stage, probabilistic stage, and deductive hypothesis stage to improve physics skills (Utami, Supeno, & Bektiarso, 2019). Several previous studies have integrated specific strategies in enhancing students' thinking skills in the problem-solving process (Nana & Pramono, 2019); (Aprilia, 2020); (Murningsih, Masykuri, & Mulyani, 2016); (Pertiwi, 2018); (Rizqa & Harjono, 2020); (Rangkuti & Sani, 2021); (Malik, Ertikanto, & Suyatna, 2015); (Nasution, 2018); (Sulistiyono, 2020); (Sukma, Komariyah, & Syam, 2016). Inquiry learning model implemented to reduce misconceptions in physics learning. Students become more active, creative and find solutions to solve problems (Aprilia, 2020).

Using the keyword *"Inquiry Learning Models in Physics Learning"* has a relationship with learning outcomes, learning environment, research methods, learning systems, critical thinking skills, quasi research, and research methods. Knowing how big the connection of Inquiry is, it can be seen in Figure 3.



Figure 3 Visualization of Inquiry Learning in Physics on *VOSviewer* with Network Visualization

Based on the results of the visualization on the *VOSviewer*, there is a relationship between each keyword. These keywords have different colour characteristics. The red colour indicates the density or number of keywords that appear in each research. So based on this, the implementation of Inquiry that is widely studied is related to students. Meanwhile, green is the second largest number of keyword characteristics, which explains the learning process activities.

This *VOSviewer* visualization only shows the relevance and density of Inquiry research on the abilities and skills of students. Based on this inquiry learning model's physics experiment study results, the existing implementation's effects have not been mapped out.

Thus, a re-analysis is needed to determine how much influence the inquiry learning model has on physics learning applied to students. This description was conducted with a meta-analysis study on the inquiry learning model in physics learning. This research can be done by examining the results of the existing analysis in-depth so that the results of this study can be used as a reference for teachers to apply the inquiry learning model to physics learning appropriately and effectively. Therefore, this paper aims to discuss the "Meta-Analysis Studies of Inquiry Learning Models in Physics Learning”.

# **METHOD**

The type of research used is library research to analyze the presentation of scientific publications in national electronic journals about the influence of inquiry learning models on physics learning using the meta-analysis method. Meta-analysis is a statistical analysis technique of research with research data summarized, reviewed and analyzed from the results of previous studies. After that, data collection is done by browsing articles in journals, thesis results, and theses in the repository(Anadiroh, 2019)*.*

The results of statistical analysis techniques describe two or more research data so that quantitative data is obtained. It is from an extensive collection of individual study analysis results integrating findings. This study uses statistical methods by combining the data from previous studies for review. From the results of previous studies, meta-analysis using the effect size technique has been proven. Its accuracy is proven where the metadata results can be tested for their effectiveness and used to calculate the effect size. The effect of treatment of the two variables involved can be shown and then can be mapped to be analyzed for the impact involved. So the results of the effect size in each study found how much influence the treatment had.

The population used in this research is scientific publication articles in national-scale journals about the inquiry learning model. In contrast, the sample used is a scientific publication (national accredited) on inquiry learning on physics learning. The method used in the article is experimental research and meets the statistical effect size data.

The stages of this research are by the meta-analysis steps shown in the research flow chart in Figure 4.

Determining the research topic, namely the Inquiry Learning Model in Physics learning

Setting data selection criteria

Search for articles based on criteria

Define articles and then group information from the data

Analyze article with *effect size*

Summarizing meta analysis data

Figure 4 Meta-Analysis Flow Stages

Data collection techniques in the form of secondary data from previous research articles with the following criteria: 1) inquiry learning model in physics learning, 2) articles from national journals accredited by Ristekdikti in Sinta Indonesia (S1-S4), 3) the research uses a quasi-experimental, 4) must meet statistical data in calculating effect size. Data collection is made more accessible by using data coding, where the data search process uses a coding instrument to match the criteria and meet the requirements explicitly (Cooper et al., 2019).

The analysis technique used is a descriptive statistical technique with effect size calculation. Effect size is a value used to calculate the magnitude of the treatment of the relationship between two variables in the meta-analysis. If the research uses two groups of variables, namely the control group and the experimental group with the t-test as a comparative analysis, then the effect size calculation is obtained using the eta-square equation ($η^{2}) $as follows:

$η^{2} $= $r^{2}$ = $\frac{t\_{0}^{2}}{t\_{0}^{2}+db}$ (1)

(Kadir, 2017)

After conducting experimental research, it is obtained the assumption of a heterogeneous group with two group variables, the calculation of effect size can be calculated through the following equation:

$∆ = \frac{\overbar{X}\_{E}-\overbar{X}\_{K}}{S\_{K}}$ (2)

Glass on (Kadir, 2017)

The results of the calculation of effect size can be interpreted in terms of criteria by using references from Gravetter and Walnau in (Anadiroh, 2019) as shown in Table 1.

Table 1 The Effect SizeCalculate Result

|  |  |
| --- | --- |
| **Effect Size** | **Criteria** |
| 0.01 < *Effect Size* $\leq $0,09 | Small Effect |
| 0.09 < *Effect Size* $\leq $ 0.25 | Medium Effect |
| *Effect Size* > 0.25 | Big Effect |

# **RESULT AND DISCUSSION**

Meta-analysis research using 23 relevant articles. The data collection was analyzed using the effect size method in knowing the influence of the inquiry learning model in physics learning. Table 2 shows the results of the calculation of the effect size from 23 relevant articles. Of the total articles categorized into effect size, there are two articles with effect size values belonging to the small category, three articles with effect size values belonging to the medium category and eighteen articles with effect size values belonging to the large.

Table 2 The Effect Size Average Value on Relevant Articles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Code** | **Effect Size** | **Category** | **N** |
| 1. | 1A | 0.041 | SmallEffect | 2 |
| 2. | 10A | 0.023 |
| 3. | 2A | 0.145 | MediumEffect | 2 |
| 4. | 44A | 0.248 |
| 5. | 4A | 0.960 |
| 6. | 5A | 0.500 | Big Effect | 18 |
| 7. | 18A | 0.310 |
| 8. | 21A | 0.432 |
| 9. | 25A | 0.515 |
| 10. | 27A | 0.400 |
| 11. | 31A | 0.780 |
| 12. | 38A | 0.800 |
| 13. | 42A | 1.710 |
| 14. | 43A | 4.490 |
| 15. | 45A | 8.700 |
| 16. | 46A | 0.540 |
| 17. | 48A | 1.600 |
| 18. | 50B | 0.900 |
| 19. | 55B | 1.380 |
| 20. | 60B | 0.850 |
| 21. | 63B | 0.444 |
| 22. | 67B | 1.009 |
| Average Effect Size |
| **1.216** |  **Big Effect** |

The value of the 23 relevant articles is accumulated so that the overall effect size value is obtained, that is, 1.216, which is included in the large effect size category. That way, there is a significant influence in implementing the inquiry learning model in physics learning.

Articles are grouped based on each level of education, namely University, Senior High School, Junior High School, and Elementary School, and undefined. Each class is calculated by value and classified into effect size, as shown in Table 3. Of the five types of grouping based on education, each has an effect size value in the large category. The effect size value based on education level has a powerful influence on implementing the inquiry learning model in physics learning.

One of the factors that influence learning activities is selecting a suitable model. As one example, it can be applied in learning at the elementary education level. Improving the quality of Human Resources is essential in facing the development of science and technology, which at the elementary school level plays a critical role in improving the quality of Human Resources (Sumantri et al., 2017)

Table 3 Effect Size Based on Education Level

|  |  |  |
| --- | --- | --- |
| **Educational Level** | **Effect Size** | **Category** |
| University  | 0.444 | Big Effect |
| Senior High School | 0.985 | Big Effect |
| Junior High School | 0.800 | Big Effect |
| Elementary School | 2.895 | Big Effect |
| Undefined | 1.380 | Big Effect |

In learning activities, which are part of the educational process, several problems hinder the progress of education, one of which is the low quality of education. Thus, to overcome these problems, it is necessary to improve the learning process. In the learning process, students can be actively involved in finding and finding their issues or concepts that they must understand by emphasizing the process and learning outcomes. This learning model plays an active role where students can find their answers to the problems they are investigating and make students understand abstract concepts and are more easily absorbed by them. Individual development is influenced by the process of assimilation, accommodation, and equilibrium. The assimilation method occurs when students receive new information or experiences, adjusted by the cognitive structure. The accommodation process occurs when students adapt cognitive systems to newly acquired knowledge or experiences. Then the equilibrium process, which is commonly referred to as equilibrium, occurs continuously when assimilation and accommodation are carried out (Sutarto, 2017). Student learning outcomes have increased in each cycle. The use of the inquiry learning model is associated with several aspects. That is explaining understanding, analyzing grouping properties of objects, proving the distance between objects and field strength, classifying grouping objects so that there is an increase in learning outcomes, as well as the achievement of the targets set for students at the elementary school level (Setiasih & Panjaitan, 2016).

Table 4 Effect Size Based on the Result of the Article Research

|  |  |  |
| --- | --- | --- |
| **Research Bound Variables** | **Effect Size** | **Category** |
| Motivation Learning | 0.041 | Small Effect |
| Learning outcomes | 1.350 | Big Effect |
| Critical thinking | 0.515 | Big Effect |
| Concept Understanding | 1.477 | Big Effect |
| Cognitive and Affective | 0.310 | Big Effect |
| Learning Model | 0.960 | Big Effect |

Table 4 shows the grouping of articles based on variables and calculated and categorized in terms of effect size. From the results, there is an effect of the implementation of the inquiry model in learning physics that has a significant impact on student motivation, student learning outcomes, critical thinking, understanding concepts, cognitive and affective, and learning models. Meanwhile, based on the response variable, it has an effect size in the significant effect category. Understanding student concepts is the ability of students to grow the meaning of learning materials, such as the meaning that is spoken, written and illustrated. In this case, students can reveal and explain the information received and then develop it using their own words.

From the effect size calculation results based on the dependent variable of research in relevant articles, it was found that students' conceptual understanding had the highest number of effect sizes of 1.477 and belonged to the large category effect size. Students' understanding reaches the level of concept understanding if they meet the criteria and indicators. These indicators include interpreting, exemplifying, classifying, summarizing, comparing and concluding. That way, students are said to have understood the concepts of learning material if they have reached the indicators of understanding (Adam et al., 2016)

Meanwhile, learning motivation has a negligible effect with an effect size value of 0.041. Increased learning motivation, of course, other factors influence. Factors in increasing learning motivation are extrinsic factors and intrinsic factors. The motivation that comes from students achieving physical and psychological readiness in learning is called intrinsic motivation. In contrast, the motivation that comes from outside supporting environments such as parents, friends, and educators is included in extrinsic motivation. Therefore, the attitude given by students is different for each individual and is influenced by the acceptance of the material received differently. Responses to the material given to students can be positive and negative, which depends on social conditions (Putri & Rifai, 2019)

Table 5 Effect Size Based on Subject Matter

|  |  |  |
| --- | --- | --- |
| **Subject Matter** | **Effect Size** | **Category** |
| Simple Harmonic Motion | 0.700 | Big Effect |
| Heat | 0.420 | Big Effect |
| Optic | 0.688 | Big Effect |
| Work and Energy | 1.055 | Big Effect |
| Science  | 0.432 | Big Effect |
| Solar System | 0.78 | Big Effect |
| Dynamic Fluids | 4.49 | Big Effect |
| Properties of Light | 5.15 | Big Effect |
| Earth's Revolution and Rotation | 0.85 | Big Effect |
| Newton's Law | 0.444 | Big Effect |
| Static Fluids | 1.009 | Big Effect |
| Undefined | 0.864 | Big Effect |

Table 5 shows the article data grouped by subject matter, and the results obtained are effect size and classified in effect size*.* In the classification of effect size based on the subject matter, various types of learning material. Including Simple Harmonic Motion, Heat, Optics, Work and Energy, Natural Sciences, Solar System, Dynamic Fluids, Properties of Light, Revolution and Earth's Rotation, Newton's Laws, Static Fluid, and undefined material in the articles. These materials have effect size values ​​in the large category. That way, the types of material with large varieties can be related to real-life problems and are accurate. The properties of light are the materials with the highest effect size values ​​that influence the implementation of Inquiry in physics learning. In real life, of course, we often encounter things that cannot be separated from light and are related to light which in everyday life, light can provide the most role for human life.

So that if it is associated with material related to the properties of light in everyday life, students will undoubtedly be easier to accept the material when compared to other materials. Research by Nur et al. (2019), Muspratiwi et al. (2018), Verdiana et al. (2019) also chooses light material in the implementation of the Inquiry. Then the Dynamic Fluid material belongs to the second significant effect after the light material, with an effect size value of 4.49. Fluid dynamics have a fundamental role in explaining physical phenomena that occur in real life. Natural events are easy to find in everyday life, making it easier for students to accept the delivery of dynamic fluid material in physics learning (Nisa, Yuliati, & Hidayat, 2020). In other cases, undefined learning materials were also found in some articles. This unspecified material is classified as a large effect size because it has an effect size value of 0.864. The unclear material can occur because of general material applied in elementary or university learning.

Table 6 Effect Size Based on Learning Media

|  |  |  |
| --- | --- | --- |
| **Learning Media** | **Effect Size** | **Category** |
| Student’s Exercise  | 1.652 | Big Effect |
| Simulation | 0.441 | Big Effec |
| Video | 0.432 | Big Effect |
| Instrument | 0.032 | Small Effect |
| Undefined  | 0.710 | Big Effect |

Table 6 shows the relevant articles grouped by learning media to calculate and categorize effect size. The learning media used in the student learning process is classified as an effect size with a large effect category. Student worksheets are classified as the learning media with the most decisive influence in this learning media, where the effect size value is 1.758 in the inquiry learning model. Learning resources in learning that are often used can be printed teaching materials that encourage and facilitate students in education. One of the printed teaching materials is the worksheet. The worksheet is a means of helping teaching activities to form effective interactions between students and teachers, thus forming activeness in students in improving learning achievement. The use of worksheets in learning has benefits in improving students' science process skills. Students can develop scientific attitudes and foster student interest in education. Besides that, worksheets are also used as a means for teachers to increase student involvement in teaching and learning activities. Thus, students can play a more active role, and learning is student-centred.

Furthermore, the learning media used is not specified or referred to as undefined. In this case, it is classified as a significant effect because it has an effect size value of 0.710. This vague learning media is listed because articles do not specify the learning media used, usually only involving the type of material and level of education.

**CONCLUSION**

From the analysis results in this meta-analysis, it is concluded that the application of Inquiry has a significant effect on learning physics, the results of which are large effect size values. The implementation of inquiry on physics learning has a substantial influence if applied at the elementary level. It produced output that can improve students' understanding concepts by using the subject matter of the properties of light and assisted by real learning media in the form of worksheets.

It is hoped that the results of this study will become a recommendation for the preservice physics teachers, teachers, or education practitioners in applying the inquiry learning model in physics learning. So that students become more active, have high - order thinking skills, and understand more about physics concepts.

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